have done. Independently, therefore, of this primary distinction (which of itself would be sufficient to separate them), I may just add that the *C. spretus* may be known from its ally by (on the average) its slightly larger bulk and rather darker hue; by its prothorax being perhaps a little less rounded at the sides, and its elytra a little *more* so; and by the latter being just perceptibly more convex and opake, with their basal line somewhat straighter.

Whilst the *C. barbatus* is apparently confined to Grand Canary, the present species has been observed only in Hierro, where several specimens of it were captured by Mr. Gray and myself during our visit to that island in February 1858.

XXXIX.—*On the Microscopic Life of the Island of St. Paul, in the Southern Ocean.* By Professor Ehrenberg*.

Oases in great deserts, and islands of difficult access in the distant ocean, often fill the naturalist with a longing desire for a knowledge of the forms of life existing on them. It seems as if something of a virgin nature—something primæval, and not yet profaned by man—might possibly be retained there, the knowledge of which might enable us to see more deeply into the original manifestations of life on our planet. On the other hand, the expectation at least will be excited of finding, together and connected in isolated spots, certain natural variations of a simpler type of life, which elsewhere have been altered by innumerable opportunities of intermixture, until the original forms have become unrecognizable. It is with a feeling of devotion, with a beating heart, that the naturalist, whether young or old, approaches such localities as are closed to common intercourse, regarding them in the light of something sacred. Experience and the quietude of advancing years cool many a warm hope; but the idea constantly awakens freshly that on some distant island some treasure of this kind is to be found,—just as New Holland has retained its Marsupial Mammals, and New Zealand and Madagascar their gigantic birds—living in the one case, in the others scarcely dead.

The small Island of St. Paul, situated in the midst of the Southern Ocean, at nearly an equal distance (3000 nautical miles) from the Cape of Good Hope and Adelaide in New Holland, which was first discovered and named by Antonio Van Diemen, in 1633, as the southernmost of the two islands of Amsterdam

* Translated from the 'Monatsbericht der Berliner Akademie der Wissenschaften,' December 1861, p. 1085.

and St. Paul, has recently been examined with the most devoted zeal and care, at the special desire of Alexander Von Humboldt, by the Austrian circumnavigatory expedition of the frigate 'Novara.' The great distance of this island from the active traffic of the world, and the already published review of the larger forms of life accessible to the naked eye, induced me to submit the cinders and samples of earth sent to me by Professor Hochstetter, the geologist to the expedition, to a careful examination in respect of the microscopic forms of life; and I desire now to append the results of this investigation, as an expression of thanks to the unwearied and most meritorious efforts of that observer.

SHORT DESCRIPTION OF THE ISLAND.

[From the journals of the 'Novara,' by Dr. Scherzer.]

The greatest length of the Island of St. Paul, which, according to the recent observations, is situated in 38° 42′ 55″ S. lat. and 77° 31′ 18″ W. long., is three nautical miles; its greatest breadth, from S.E. to N.W., two nautical miles; and its total surface 1,600,000 square fathoms. Its form is that of a simple crater-wall surrounding a nearly circular crater-lake, the latter being 3984 Viennese feet in greatest breadth, and 34 fathoms (=204 feet) in depth. The highest point of the crater-margin is 846 Viennese feet above the level of the sea.

The rocks are basaltic lavas, consisting of glassy oligoclase and augite, with intermixed olivine and magnetic iron. From a sharp profile on the eastern side, the petrographic structure of the island may be clearly seen. Here four principal periods of the geological development of the island make their appearance, three submarine and one supramarine, of which more accurate proof is desirable. At present the island is only in the state of a quiescent fumarole. Pure aqueous vapours, without any trace of vapours of sulphurous and muriatic acids, flow forth from the clefts of the inner margin of the crater, and, on the summit of the island, from the fissures of the newest bed of lava.

With regard to the period of the last great geological change, it appears, from the journals of the 'Novara' of the year 1857, that 160 years previously (namely, in 1697, when the Dutch captain Willem de Vlaming saw the island) the entrance to the crater-basin was still closed by a dam 5 feet in height, and that at the present day this entrance is open, for a width of 306 feet, for the admission of boats at all times of the day, and has a depth of 2–3 feet of water at ebb-tide, and of 9 feet at the flood. Whether storms and the action of the waves during the last 160 years have broken down the dam, or whether an internal volcanic movement has assisted in producing the effect, may re-

main doubtful; the alteration in that time is certainly attested. The flames and masses of smoke observed by d'Entrecasteau for two whole days in 1792, on the neighbouring island of Amsterdam, were repeated before the eyes of the naturalists by the accidental ignition of the dry grass, depriving the supposition that the islands were active at that time of its probability.

THE LARGER FORMS OF LIFE.

Great was the anxious suspense of the body of scientific men as they approached the island. As soon as the anchor was dropped, a small boat was seen approaching, with three wild-looking men in it. These human inhabitants were neither aborigines nor shipwrecked seamen, but Frenchmen, voluntary colonists from St. Denis in the Isle of Bourbon, who, for the sake of the fishery, had established themselves near a spring, in the same way as the two sea-bear-hunters who were found settled there, in 1793, by the English man-of-war 'Lion,' and who had remained for more than a year. Twice in the year a ship enables the French colonists to communicate with the Mascarene Islands.

The examination of the island, continued during two weeks and a half by the whole scientific body landed there on purpose, has furnished us with an exhaustive view of all the larger forms of life of this isolated extinct volcano.

Of vegetable forms St. Paul contains neither tree nor shrub; but poppies, parsley, potatoes, and oats, growing wild, gave testimony to the previous settlement of Europeans. Of plants in general, besides the introduced cultivated species and their constant companions *Sonchus arvensis, Digitaria, Plantago, Ceratium,* and *Stellaria media,* the whole island presented 56 species independent of man,—namely, 11 probably aboriginal Phanerogamia (6 Grasses, 1 Cyperacean), 2 Ferns, 1 *Lycopodium,* 3 Mosses, 2 Liverworts, 4 Lichens, and 33 Algæ. The grasses form no meadows but the plants are only closely approximated; nevertheless they constitute the general covering of the soil. Their decay forms the mould, which is sometimes several feet thick.

Of peculiar Mammals there was no trace; but there were pigs, goats, cats, and rabbits, which had become wild, and also rats and mice. The sea-bears (*Arctocephalus falclandicus*), which were formerly abundant, have disappeared, although as late as 1793 the colonists found there were completing a cargo of 25,000 skins, as many animals came daily to the shore.

Of Birds, a peculiar Tern (*Sterna*), a Skua (*Stercorarius antarcticus*), the Broad-billed Petrel (*Prion vittatus*), three species of Albatross (*Diomedea exulans, D. chlororhynchus,* and *Phœbetria fuliginosa*) were observed and collected. A species of Pen-

guin (*Eudyptes chrysocoma*) was remarkably abundant. With these widely distributed oceanic birds, there was only a single land-bird, a Swift (*Cypselus*); and the male appeared to be in attendance upon a sitting female.

Of Fishes, a large Acanthopterygian (*Cheilodactylus fasciatus*), allied to the Umbre, constituted the principal object of the sea-fishery. With the hook, *Thyrsites Aton* and a few other forms were taken in the ship; and there were also Sharks.

Of Amphibia the island showed no trace.

Of Insects, with the exception of the introduced Clothes-Moth, there were no *Lepidoptera*; nor were there any *Hymenoptera*, *Neuroptera*, or indigenous *Orthoptera*. There were only one small ground-Beetle, two abundant Spiders, and one very small Homopterous insect (*Delphax hemiptera*). There was also a species of the Isopod Crustacea, and with it our common Wood-louse (*Porcellio*); the Book-louse (*Psocus*), Earwig (*Forficula*), and Flea were also present, and appeared to have been introduced. The Woodlouse was astonishingly abundant, covering the island in such dense masses that one of the naturalists estimated its numbers at 6,000,000,000, assuming 100 specimens as the minimum on one square foot of surface. About the fumaroles they always lay in heaps, dead and scorched. The similar absence of all Butterflies, Sphinges, and Bombyces in Iceland was explained by my late friend, the learned traveller and naturalist, Dr. Thienemann (Reise, 1827, p. 240), by their being more easily destroyed by showers of ashes; whilst *Noctuæ* and *Geometræ* exist in Iceland, and Butterflies live still further to the north.

Of the higher Crustacea, a large *Palinurus* was very abundant in the sea, and proved to be very good eating. The Mollusca, which were not plentiful even in the dredge, were mostly very small. The largest was a *Tritonium*, 3 inches in length, taken in the sea. There were 3 small Brachiopods.

The sum-total of the species of animals enumerated in the general account of the voyage scarcely amounts to 20, independent of human agency.

However possible it might be to add a few fishes and some parasites of the widely distributed birds and of the fishes to the fauna of the island, or to catalogue marine shells and worms in larger numbers than were furnished by the dredge, still the terrestrial fauna, which particularly interests us, has been in fact settled at the above small number of forms by remarkably expert and zealous observers. A few insects which had concealed themselves during stormy and rainy days might probably come forth in the quiet sunshine; and at other seasons of the year a few more species of animals and plants might be collected, which were in-

visible in November and December; but the number of 76 indigenous forms of the larger plants and animals appears to be very nearly the extreme limit of the palpable life of the island, and may be adopted here only as a standard of comparison with the microscopic impalpable life.

THE MICROSCOPIC FORMS OF LIFE.

Professor Hochstetter sent me first of all some specimens of cinders and earths from the base and the elevated surface of the volcano. The increasing interest of the investigation induced me to make special requests, and called forth from Professor Hochstetter further explanations and the transmission of other materials. In this way I obtained fifteen different samples.

Review and Characteristics of the Materials.

a. *From the shore and base of the crater.*

1. *Sand from the hot place close to the shore of the crater-basin.* No. 171.—The spot is covered by the sea at high water. At a depth of $\frac{1}{2}$–1 foot, the thermometer rose to 168°, 187°, 196°, 197°·6, and 201° F. The bare foot could not bear to rest on the surface, and was scalded when slightly sunk. The specimen is dry, and consists of a moderately fine sharp sand of a dark-grey colour, with numerous black, yellowish, and white grains, mostly a little coarser than ordinary writing-sand. Acids produce no perceptible effervescence. When heated to redness, many of the dark particles become paler, and the brown ones more yellowish. Ten analyses of the finest parts, suspended in distilled water, gave only a slight intermixture of organic particles in a greatly predominating mass of sand composed of cindery fragments of different colours, many of which were doubly refractive. Only two Polygastria and three Phytolitharia could be particularly registered; they were all completely isolated. From the scanty intermixture of the latter, this sand evidently has no connexion with the humus of the island; and although the two Polygastria establish beyond a doubt a connexion with the neighbouring sea, all the intermixed calcareous particles of sea-sand are wanting. The sand consequently consists of fine cindery particles, and of a few accidentally introduced terrestrial and marine organisms of the smallest size.

Each of the analyses here given relates, as in other cases, to about one-third of a cubic line (a portion as large as a pin's head) of the mass, spread thinly with water upon mica, dried, and coated with Canada balsam: every particle of this, however small, was examined with a power of 300 diameters.

2. *Stone from the hot spring, coated with calcareous incrustations and Oscillatoriæ.* No. 167.—I have received two breccia-like, coarsely granular, but not porous specimens of stone, nearly 2 inches in diameter, exhibiting, in a black fundamental mass, white amorphous grains, often 1 line in diameter, and sometimes separable, which are glassy at their margins, but mostly opake in the middle. The spring has a temperature of 131° F., a somewhat alkaline reaction, and a strongly mineral taste. At high water it is covered by the sea. The specimens have formed the walls of a natural supply-pipe. Muriatic acid dissolves a portion of the incrusting coat with effervescence; a considerable portion remains unaltered. Of the latter a portion is felt-like, and composed of very delicate organic elements; another portion is earthy. The felty masses are partly of a green colour (they were living), partly colourless or white (dead?). The green portions are entirely felted *Oscillatoriæ*, one of which (a very fine one) closely resembles *O. labyrinthiformis*; the other, which is rather coarser, is of a more vivid green. The pale-yellowish and white felted masses are made up of the same forms bleached, but also frequently of dense colonies of hitherto unknown forms (*Phalarina Wüllerstorfii, Cymboplea Novaræ, Collosigma Scherzeri*, and *Collorhaphis Sellenyi*), amongst which various other forms lie isolatedly. The total result of twenty analyses enables us to register, besides the *Oscillatoriæ*, 14 Polygastria, 4 Phytolitharia (of which 3 are Spongolithes) and 1 Lepidopterous scale. The new genera are mostly amorphous jellies, in which scattered and densely aggregated *Naviculacea* lie without order.

3. *Cinder from the coast, covered with Serpulæ.* X.—The fragment of cinder, rather more than 2 inches in diameter, is very porous, with the principal mass dark brown; it resembles a firmly cemented dark-brown sand, and has white enclosed grains, glassy at the margin, and not acted upon by acids, like those in No. 2. The *Serpulæ* are mostly covered with a thin green coat of Algæ. The fragment, previously freed from all foreign dust by strong blowing on all sides, was repeatedly shaken strongly, in a suitable vessel, with distilled water, by which a slight turbidity of the water was produced. In the deposit there were, in twenty analyses, 42 organic forms: — viz. 12 Polygastria, 12 Phytolitharia, 14 Polythalamia, 2 Polycystina, 1 Bryozoon, 1 Zoolitharion.

4. *Coarse black sand from the shore.* No. 154.—The sand resembles coarse gunpowder, and only contains a few whitish silicious particles. Many of the black grains follow the magnet, and appear to be a magnetic iron-sand. There were no organic forms.

b. *From the upper surface of the volcano.*

5. *Bog iron-ore from the upper margin of the crater.* Y.—The sample consists of some fragments, an inch or more in diameter, of a deposit resembling bog iron-ore, coarsely granular, full of holes, and of a reddish-brown colour. The weathered surface is whitish; the fresh fractures exhibit many cavities, several lines in diameter, filled with a red, ochrey, friable earth. Here and there glassy streaks of greater solidity occur in the mass. Acid is absorbed without effervescence; calcination produces no change in the red colour. After the surface had been well blown, the bright-red friable inner parts were crushed in distilled water, and, after the clear water had been poured away, boiled with muriatic acid. The fluid became greenish, and a whitish silica, free from iron, remained behind. Ten analyses of this mass furnished 16 striking organic forms:—6 Polygastria, 6 Phytolitharia, 3 Polycystina, 1 Geolithe. Decided marine forms were mixed with very striking freshwater forms, otherwise than in the other cases.

6. *Bright-red earth from the highest points of the island, under the turf.* No. 164.—The entire upper margin of the crater presents red earth of this kind, apparently the upper beds of lava and cinders decomposed into iron-ochre or brown ironstone. The sample is a bright, rusty-red, fine earth, which does not effervesce with acid, and, when calcined, becomes first blackish, and afterwards only a very little darker, at last even resuming its original colour. In washing, the greater part is suspended in the water, and only a few sand-grains remain; these, also, form rough particles between the fingers, whilst the mass is of impalpable fineness. When the red earth is boiled with muriatic acid, iron is extracted, and a white earth, scarcely diminished in volume, is left.

This earth is exceedingly remarkable when examined by the microscope. It consists, with the exception of a very few quartzose glassy sand-grains, entirely of well-preserved fine, and coarser silicious particles from grasses, with a few shells of Polygastria intermixed. That these particles, covered individually with a thin coat of peroxide of iron, which ceases to be perceptible under a magnifying power of 300 diameters, were produced, as might be supposed from appearances, by the weathering and decomposition of beds of lava and cinders, is impossible, from the sharpness and good preservation of their forms; but a baking and hardening of the decomposed grassy vegetation to form superficial cindery rocks, and an action of the volcano upon such masses, colouring them with peroxide of iron, is readily conceivable even at a high temperature; the circumstance that the oxide of iron in them is

not a hydrate, but anhydrous oxide of iron, and therefore quite distinct from the very similar iron-ochre, is favourable to this view. (Compare No. 5.) Ten analyses have enabled 25 Phytolitharia, amongst which is 1 Spongolithe and 1 Polygastrian, to be determined as *constituent* elements. The small quantity of inorganic sand is not glassy, but strongly doubly refractive; and the behaviour of its white particles resembles that of the white portion of the cinders indicated as oligoclase. The *Lithosphæridia* predominate, and are the smallest forms. *Lithostylidium rude* is large, and often very numerous. Although the *Lithosphæridia* have their outlines always sharp and smooth, the *Lithostylidia* usually appear spongy and, as it were, eaten away. One of their chemical constituents appears to have been extracted from them. The stelligerous forms, described as *Lithosemata*, occur not unfrequently.

7. *Dark-brown earth under the turf of the most elevated surfaces.* No. 166.—The fine dark-brown earth, which becomes black when wetted, does not effervesce with acids. When calcined, it becomes first blackish, and then of a darker brown than before. It contains many root-fibres of plants, which are visible to the naked eye. When washed, there remains a fine variegated sand in which many Phytolitharia are imbedded. *Lithosphæridia* are rare; but *Amphidiscus truncatus*, *Lithostylidium clepsammidium*, and *L. rude* are abundant. No *Lithosemata*. In all, ten analyses gave 4 Polygastria and 21 Phytolitharia, such as particles of grasses, but no Spongolithe.

8. *Dark-brown earth under the turf of the highest region of the island.* No. 165.—Dull dark-brown earth, which does not effervesce with acids, and, when calcined, becomes first black, and then white. Impalpable when rubbed between the fingers. In ten analyses, 24 organic forms were found; these were all silicious particles of grasses, except 1 Spongolithe, most probably blown in.

In the form, abundance, and intermixture of the forms, this earth exactly resembles the red earths Nos. 5 and 6. Only a small quantity, disappearing in the mass, of decomposed vegetable cellular tissue (true humus) is intermixed with it; but still this is the part which gives the brown colour. Iron, on the contrary, is entirely wanting. This fact is important, because by it the iron in Nos. 5 and 6 is shown to be a foreign intermixture, not appertaining to those grass-particles, and either produced by volcanic action or by non-volcanic deposition from water. The apparently black humus of the island, where quite free from volcanic dust, is only formed by Phytolitharia with a little soluble cellular matter, and without lime.

9. *Red fumarole-clay on the plateau at the highest margin of the crater.* No. 197.—The specimen is a yellowish-brown, dry, friable, clayey earth, dried into lumps, and plastic when moist, which has a sharp sandy feel when rubbed between the fingers. The colour is a rather duller red, and more like loam, than that of No. 5. On the addition of acids, no effervescence or other change is produced. When calcined, the mass becomes first blackish, then reddish brown, darker than before, and not blood-red. When boiled with muriatic acid, it becomes very pale and whitish. Under a magnifying power of 300 diameters, the mass appears like a very fine clay. Ten analyses gave only 3 recognizable forms as organic elements. By the washing of the finest clay, the sharply sandy residue in a watch-glass gave numerous *Lithostylidia*, but only a few well preserved. Various half-decomposed bacilliform fragments might belong to the same forms. The most remarkable forms were numerous spherules, often of very small size, which were unaltered by boiling in muriatic acid, round or oval in shape, very smooth and finely cellular in the interior. As I once found four of them adhering together, the middle one being smaller and also of irregular shape, I have indicated these structures as hyalithic Morpholithes. They often resemble a *Haliomma*; they contain air in their interior within numerous small cells, into which balsam gradually penetrates from the surface. With polarized light, they often, but not always, become opalescent. The latter characteristic excludes them very distinctly from the organic forms.

10. *Moss-turf from a soil of moist blackish-brown humus.* No. 6.—The sample is a dense satiny moss-turf, without fructification; it is probably a *Bryum*. After softening and squeezing a portion in distilled water, there occurred, as a turbidity, in ten analyses, 8 Polygastria (6 Diatoms) and 16 Phytolitharia, amongst which are 2 Spongolithes; together, 24 organic forms. Brown irregular particles, amongst which were many small fragments of Phytolitharia, predominate. *Pinnularia borealis* and *Lithostylidium rude* are very abundant; the rest occur singly.

11. *Bright-green moss upon black humus.* No. 7.—The sample is a moss-turf with large bright-green stems, resembling a *Hypnum*, and adherent traces of Lichens (*Cladoniæ*). Such bright-green moss showed itself on the declivities of the volcanic cone, near the highest margin of the crater, on the hottest places. When stirred in distilled water, the earth furnished, in ten analyses, 8 Polygastria and 15 Phytolitharia; together, 23 forms. Amongst much brown rotten cellular tissue, *Lithostylidia*, *Ar-*

cella globulus, and *Pinnularia borealis* are particularly plentiful; *Eunotia amphioxys* is rare.

12. *Bright-green moss-turf from a hot place.* No. 12.—A fragment of a loose moss-turf, with a slight coat of lichens (*Cladoniæ*) and various mosses, from the upper margin of the crater. In ten analyses of the finest particles, in portions of the size of a pin's head, diffused under water and covered with Canada balsam, 6 Polygastria, 18 Phytolitharia, and 1 egg of a Tardigrade, altogether 25 forms, were observed. The greatest part of the layer of humus consists of rotten cellular tissue, appearing brown by transmitted light. *Lithostylidia*, and especially *Pinnularia borealis*, are extremely plentiful, together with *Difflugia seminulum*. *Eunotia amphioxys* is not rare; the rest occur singly.

13. *Green coating on humus on moist declivities.* No. 9.—The sample consists of thin black parings of the layer of humus, with the upper surface greenish. Softened and suspended in distilled water, the fine deposit in the watch-glass showed 28 organic structures in ten portions of the size of a pin's head, namely, 11 Polygastria, 16 Phytolitharia, and 1 Tardigrade; amongst these there were cellular parts of grasses with fissures. The greater part of the Polygastria are *Arcellina*, and the two cosmopolite forms *Pinnularia borealis* and *Eunotia amphioxys*. The Phytolitharia are only portions of grasses. The Tardigrade is not rare, and cannot be distinguished from the very widely distributed *Macrobiotus Hufelandii*.

14. *Moss-turf of Sphagnum, without any earthy soil.* No. 10.—The sample consists of four clean stems, 3 inches long, without fructification. When softened in distilled water, and repeatedly squeezed, the half of them produced a slight turbidity in the water. Ten analyses of the deposit in the watch-glass furnished 6 Polygastria, 7 Phytolitharia, and 2 small seeds; together, 15 forms. *Difflugiæ* are very numerous, especially *D. seminulum* and *Frauenfeldii*; of the former there were sometimes from four to six at once in the field.

15. *Green Liverwort-turf upon moist black humus.* No. 13.—The specimen, which was about two inches across, contained chiefly *Jungermanniæ*; but amongst these there were many fern-capsules and seeds. Ten analyses of the finest earthy particles furnished 31 forms, namely, 10 Polygastria, 14 Phytolitharia, 3 Rotatoria, 1 *Anguillula*, 2 small seeds, and a portion of a plant resembling the epidermis of a grass. The *Arcellina* predominated amongst decayed parts of plants, especially *Difflugia areolata*. The Rotatoria are not rare, but never occur many together. The *Difflugiæ* appear to reside with them in the axils of the leaves of the plant.

Results.

The whole of the microscopic forms of the Island of St. Paul thus brought to light are—

Organic silicious forms.

35 Bacillariæ (Polygastria).
5 Polycystina.
67 Phytolitharia.
2 Geolithes.

Calcareous forms.

14 Polythalamia.
1 Bryozoon.
1 Zoolitharion.

Soft forms.

3 Rotatoria.
2 Tardigrada.
1 Anguillula.
13 Arcellina (Polygastria).
1 Lepidopterous scale.
7 Portions of plants.
2 Oscillatoriæ.

154

Inorganic forms.

7 kinds.

161

To these may be added isolated mouse-hairs and dyed blue and red fibres of wool, originating from the clothes of men or from filter-paper.

Of the whole 161 kinds, 76 are independent organisms; the other organic forms are characteristic parts of larger organisms, mostly grasses and sponges.

Of inorganic characteristic forms 7 are registered.

Besides these 154 organic and 7 inorganic forms, *no traces of any others could be detected* with a power of 300 diameters and even more.

The whole of the structures registered belong to the six classes already indicated in the 'Mikrogeologie' as widely distributed on the earth, and to their well-known families. But among them there are six forms which had to be described under new generic names, and which therefore may be particularly characteristic of this small island. These are the genera *Collorhaphis, Collosigma,*

Cymboplea, and *Phalarina* amongst the Diatomeæ; *Chætotrochus* amongst the Polythalamia; and *Lithosema* amongst the Phytolitharia.

In all, there are 29 forms out of the 154 which have never been observed elsewhere by me; namely, 15 Polygastria, 11 Phytolitharia, 1 Polythalamion and perhaps more, and 2 Rotatoria. Of these 18 are independent organisms.

If they be divided into terrestrial and marine forms, 48 out of the 154 organic forms belong to the sea, the remaining 106 being land and freshwater organisms.

As Tardigrada and Rotatoria were to be detected in some of the specimens, I immediately tried with great care whether they would give any signs of life in water, or whether they could be brought to full vital activity, which has usually been erroneously described as a resuscitation from death. The dry materials, which were collected in December 1857, and reached me in 1861, and were consequently more than three years old, exhibited no signs of vitality in any of the forms in which these were expected, although in previous experiments with materials from other localities I had been able to observe life still retained even for four years. We can revive no dead organisms, even the smallest!

There is, however, no doubt that the independent microscopic life of the island cannot be regarded as completed by these 76 independent forms. By observations quietly and specially directed to them, the stagnating snow and rain-water or the muddy earth, however little it may strike the eye, may present numerous other forms which disappear after death, as I found to be the case in the deserts of Africa forty years ago.

Of the 76 independent minute forms, 8 are shelless animals (Anguillulæ, Rotatoria, and Tardigrada), 13 Arcellina with membranous carapaces, 40 silicious-shelled (Diatoms and Polycystina), and 15 calcareous-shelled (Polythalamia and Bryozoa).

Several of the independent forms bearing silicious shells are very numerous in their localities; but there exists no Kieselguhr, tripoli or polishing-slate formed by them. On the contrary, the so-called humus-soil is formed principally of the 57 silicious particles of grasses, some, however, with *Naviculaceæ*.

As, according to the investigations of the botanists of the expedition, there were only 11 indigenous Phanerogamic plants and only 7 grasses upon the island, the whole of the 57 silicious particles of grasses which form the upper soil under the turf are undoubtedly derived from these 7 grasses. The few isolated Spongolithes belong to the sea, and never contribute much to the mass.

The grassy soil or humus, which in the upper parts of the

island resembles Kieselguhr, and consists chiefly of Phytolitharia, is black when moist, brown when dry; but in the vicinity of the fumaroles it is often of a bright ochreous rusty red (Nos. 6,7,8). By ignition, the black earths become not red, but white. The iron is therefore no constituent of the Phytolitharia, but an extraneous constituent introduced no doubt by the volcanic fumaroles. If the rusty-red earth, which, as reported, appears here and there to be a product of the weathering of bog iron-ore and brown ironstone, behaves everywhere like the samples, we are compelled, on account of its organic composition, to reverse the notion, and to regard the rocks standing in connexion with such earths as consisting of the latter repeatedly baked, hardened and metamorphosed.

The slight mixture of the Phytolitharian humus with inorganic sand and volcanic ashes appears of importance. From this we may undoubtedly draw many conclusions as to the activity of the volcano. If the average annual mass of the humus can be ascertained, we shall be able to judge approximately, from the thickness of the earthy mound, of the last period of repose of the volcano. Showers of ashes must have immediately effected a great change in such pure Phytolitharian humus. The samples, however, relate to considerable depths in the mass, and not to the immediate surface.

Further, the earths and rocks investigated allow us to express the opinion that the looser earthy coverings of the mound, whether black or red, are freshwater formations. With the exception of No. 5, all the marine forms registered are from points on the shore within high water. No considerable action of the sea upon the soil produced by the grassy vegetation and the uppermost rocks dependent upon this is anywhere indicated by the intermixture of marine forms; consequently the union of the crater-lake with the outer sea, produced since the year 1697, cannot lead us to the conclusion that a rising and swell of the sea touching the upper part of the land has formerly taken place.

The rock No. 5 from the upper margin of the crater (846 ft.) appears to be particularly interesting. It resembles a bog iron-ore, and has been so described by me. From its rich marine organic admixture, it appears to me, in the midst of the freshwater formations, as the ancient sea-bed, which the volcano has forced up, with little change at the time of its elevation, and impregnated with oxide of iron. Perhaps other materials in the collections of the 'Novara' may furnish further evidence, especially as to the thickness of the mass.

It is eight years since I registered, from Kerguelen's Land, situated still further towards the south pole, 56 microscopic

forms, of which 22 species were figured. These investigations were published, in 1854, in the 'Mikrogeologie.' According to this, St. Paul's and Kerguelen's Land have 23 forms in common, namely, 14 Polygastria, 8 Phytolitharia, and 1 Anguillula. In Kerguelen's Land there was one new genus, *Disiphonia*, of which the same species has recently occurred again on Mont Blanc (1859, Monatsber. 779), and a second species in New Zealand (1861, Monatsber. 887). In St. Paul's 5 peculiar genera have been discovered; and it may be worthy of notice that the *Difflugia seminulum*, registered by me from Monte Rosa and the Himalayas, has been brought from St. Paul's in great abundance, together with 9 or 10 other species, some of which are new.

According to the existing indications of its substance as far as they could be tested, the Island of St. Paul does not belong to the lands which were above the water before the last great geological catastrophe; it appears to be a volcanic elevation of a more modern, although prehistoric period. *All the new genera of microscopic independent beings belong to mineral waters and salt water, and not to the land.* The *Lithosemata* are silicious particles of grasses, one of which has been formerly described and figured by me as *Lithostylidium comtum* of the trade-wind dust, and another as *Lithostylidium ornatum*. Traces of quite unknown and peculiar types of organic life, such as are exhibited by New Holland, New Zealand, and Madagascar, are wanting in St. Paul's, even amongst microscopic organisms.

From all the specimens examined, however, it appears that in St. Paul's an abundant, earth-forming, invisibly powerful organic life is going on. Whoever is inclined to regard the invisible as unimportant will leave it unnoticed. For my part, I cannot but regard this newly opened isolated focus of powerfully active minute life with deep interest, and wish much that many travellers may be incited to assist as much as lies in their power in the further elucidation of the great invisible rock- and earth-forming life of Nature. Perhaps the present communication may serve to bring to light certain points of view which may be capable of awakening interest in many ways.

XL.—*On the* Archæopteryx lithographica, *from the Lithographic Slate of Solenhofen.* By Hermann von Meyer*.

Feathers, or indeed any remains of birds, have hitherto been known in no rock older than the Tertiary period. Reports of greater antiquity have not been confirmed. Either the speci-

* Translated from Palæontographia, vol. x. p. 53, by W. S. Dallas, F.L.S.